SATCULT Project: Good Practice Documentation Template

The application of satellite data in cultural heritage (CH) protection is still in its early stages, predominantly utilised by archaeologists. However, the SATCULT consortium has begun exploring its potential future uses in the wider CH area.

As part of an upcoming vocational training programme for CH practitioners , the SATCULT initiative gathers examples of Good Practices which show how satellite data can be used for the protection of CH including the benefits of accessing and utilising this data, and required skills for effective use. We are specifically interested in Good Practices from CH beyond archaeology.

The primary focus will be on desk research, collecting examples from European and international contexts with the assistance of Geoinformation and CH protection experts and practitioners. These examples will be analysed to determine the training needs of professionals and practitioners in CH protection and compiled into a compendium.

Please note filling this template requires knowledge to address properly the fields described throughout the survey. Although it is not long, it might take around 15 – 20 minutes to complete it thoroughly and properly.

A selected number of Good Practices, representing the working areas in cultural heritage, will be published in a European brochure and all Good Practices will be published on the SATCULT homepage and presented in the SATCULT LinkedIn group.

SATCULT:
Closing a knowledge gap by vocational training about satellite-based services in cultural heritage preservation

Erasmus+

media k | Consiglio Nazionale delle Ricerche | Spc Istituto di Scienze del Patrimonio Culturale | ERATOSTHENES CENTRE OF EXCELLENCE

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.
Project number 2024-1-DE02-KA210-VET-000244931

Name/Title of the Good Practice *

Pattern Extraction Methods and LiDAR Technology for Analyzing and Mapping Archaeological Looting

Name of the organisation *

ISPC-CNR

Type of organisation in charge of the Good Practice *

- ○ Cultural Heritage organisation
- ○ Cultural Heritage site
- ○ Cultural Heritage -related public entity (Ministry, Prefecture, Municipality)
- ○ University
- ◉ Research Institute
- ○ Earth Observation -related organisation
- ○ Geo-Informatics (Geomatics) organisation/company
- ○ Private Company
- ○ Άλλο: .....

Domain of organisation's activities/expertise *

- ○ Cultural Heritage
- ○ Archaeology
- ○ Earth Observation
- ◉ Geo-Informatics
- ○ Άλλο: .....

Contact Information and Organisation's Logistics

Respondent's contact details

Full name of the contact person *

Maria Danese

Email address *

maria.danese@cnr.it

Telephone number *

0971427328

Organisation's details

Country *

Italy

City *

Tito (Potenza)

Address *

Contrada Santa Loja

Information about the Good Practice

Please name below the *Country*, *City* and *District* where the Good Practice took place *

San Giovenale, near Rome, Italy

Please provide below a *Google Maps link* or *GPS coordinates* to the Good Practice's location *

https://maps.app.goo.gl/QYZqd2awTKZZx7Ye6

Is this considered a sensitive* area ? *
*(protected, fragile, has restricted access, or located within a conflict zone, etc.).

Please elaborate further.

Although there is no explicit reference to its classification as a 'sensitive area', it is certainly in the vicinity of a site of great historical and archaeological value

Who owns the cultural asset (ministry, other public body, private institution, none), on which the Good Practice was applied ? *

The near San Giovenale archaeological site is managed by the Italian Ministry of Culture

Date(s) or period the Good Practice took place *

Please insert below the period when the good practice held. (eg. 2019-2020, March 2020 – June 2021, etc.)

2021-2022

Description of the Good Practice *

Please describe how the satellite data were collected (please mention the repositories or services where you acquired them); how they were used in your project; which were the aims of your study; and why these data were useful towards your research goals. (character limit: 1500)

In this study, LiDAR data were acquired in September 2010 using a RIEGL LMS-Q560 full waveform scanner mounted on a helicopter, covering 6 km² in the San Giovenale area (Northern Lazio, Italy). The data, with a density of 20 points/m² and high spatial accuracy (25 cm xy, 10 cm z), were processed using Terrasolid's Terrascan software to generate a Digital Terrain Model (DTM). The aim was to detect and map archaeological looting in a densely vegetated area, where traditional optical remote sensing is ineffective. The methodology combined visualization techniques (e.g., Hillshade, Openness, Sky View Factor) with a pattern recognition approach based on the Geomorphon algorithm, which classifies landforms to identify looting-related depressions. Field validation using RTK GPS confirmed the method's high accuracy (85–95%). This approach enabled the semi-automatic detection and quantification of looting pits, offering a scalable and replicable model for monitoring cultural heritage threats in forested landscapes.

Why is this considered a Good Practice for making satellite data beneficial for Cultural Heritage ? (character limit: 1500) *

This study demonstrates a replicable and semi-automatic methodology for detecting archaeological looting using LiDAR-derived DTMs, particularly effective in wooded areas where optical imagery fails. The integration of advanced visualization techniques and the Geomorphon landform classification allowed for the identification of looting pits based on their micro-topographic signatures. This method enhances the ability to monitor and quantify clandestine excavations, which are a major threat to cultural heritage. By enabling the detection of looting even under dense vegetation, it supports proactive heritage protection and site management. The approach is cost-effective, requires limited training data compared to deep learning methods, and can be applied to other sites. Its validation through field surveys further confirms its reliability. This practice exemplifies how satellite and airborne data can be transformed into actionable tools for cultural heritage preservation, especially in areas previously inaccessible to traditional archaeological methods.

Required skills section

Skills required to conduct the Good Practice *

Please reflect here which skills – e.g. technical, technological, social, heritage-related – are/were needed for the successful implementation of this Good Practice.

Technical and Technological Skills: Expertise in LiDAR data acquisition and processing was essential, including the use of full waveform scanners, point cloud filtering, and DTM generation. Proficiency in GIS software (e.g., QGIS, SAGA GIS, Relief Visualization Toolbox) and remote sensing tools was necessary to apply and interpret various visualization techniques (VTs) such as Hillshade, Openness, and Sky View Factor.

Geospatial Analysis and Pattern Recognition: Skills in spatial analysis and landform classification were crucial, particularly in applying the Geomorphon algorithm for semi-automatic detection of looting-related depressions. Understanding of topographic modeling and terrain morphology supported the interpretation of micro-relief features.

Archaeological and Heritage Knowledge: A solid background in archaeology, especially in Etruscan culture and site formation processes, was vital to contextualize the findings and distinguish looting pits from natural features. Knowledge of historical looting patterns informed the selection of target areas.

Field Survey and Validation: Competence in GNSS/RTK GPS surveying was required for ground-truthing and validating the remote sensing results. This included the ability to interpret topographic profiles and conduct in-situ assessments of looting evidence.

Interdisciplinary Collaboration: Effective communication and collaboration among archaeologists, remote sensing specialists, and geomatics experts were key to integrating diverse methodologies and ensuring the reliability of results.

Are/were there any technical skills required for this Good Practice that were not initially available within your organisation and had to be acquired or outsourced? *

- ○ Yes
- ◉ No

Please list the specific skills acquired or outsourced and describe their purpose (e.g. “I learned Python to automate the downloading and preprocessing of collected satellite data.”) *

Evidence of success *

Please describe the benefits they provide to the cultural heritage asset (e.g. a site can be protected from a hailstorm, looters can be deterred from illegal excavation, damage can be recorded online through international cooperation, etc.). (character limit: 1500)

The methodology applied at the San Giovenale site demonstrated a high success rate (85–95%) in detecting looting-related features, even under dense vegetation. This enabled the identification and mapping of over 175 m² of clandestinely excavated areas, many of which had never been documented before. The integration of LiDAR data with Geomorphon-based pattern recognition allowed for the semi-automatic detection of looting pits, significantly reducing the time and resources needed for manual surveys.

This approach provides tangible benefits for cultural heritage protection:

Early detection of looting activity enables timely intervention and increased surveillance in vulnerable areas.
Documentation and quantification of damage support legal and administrative actions against illicit excavations.
Remote monitoring allows for continuous assessment of hard-to-access or forested sites, reducing the need for invasive fieldwork.
Data sharing and reproducibility foster international cooperation and the development of standardized tools for heritage protection.
Awareness and deterrence: the visibility of such monitoring efforts may discourage future looting attempts.

Overall, this Good Practice enhances the capacity to safeguard archaeological landscapes through non-invasive, scalable, and replicable methods.

Available references for the Good Practice *

Please mention below if there are any derived publications, media reports or any other content that refers to the described Good Practice. Please include also a web link if available.

(character limit: 1500)

Danese, M.; Gioia, D.; Vitale, V.; Abate, N.; Amodio, A.M.; Lasaponara, R.; Masini, N. Pattern Recognition Approach and LiDAR for the Analysis and Mapping of Archaeological Looting: Application to an Etruscan Site. Remote Sens. 2022, 14, 1587. https://doi.org/10.3390/rs14071587

Please upload 2-3 images that concern the Good Practice. *
(each image cannot exceed the size limit of the 100 MB)

img1-validations ... img2-evidence of...

Προσθήκη αρχείου

Do you own the copyrights for these images ? *

- (●) Yes
- ( ) No

Should any form of media or outreach material will be created in the future, can we use them to advertise your organization and the CH asset with proper acknowledgement? *

- (●) Yes
- ( ) No

Please provide below the credits for the picture(s): *

Danese, M.; Gioia, D.; Vitale, V.; Abate, N.; Amodio, A.M.; Lasaponara, R.; Masini, N. Pattern Recognition Approach and LiDAR for the Analysis and Mapping of Archaeological Looting: Application to an Etruscan Site. Remote Sens. 2022, 14, 1587. https://doi.org/10.3390/rs14071587

Did you encounter any technical and/or technological challenges or issues associated with the implementation of this Good Practice? E.g. missing knowledge, doubts of colleagues, financial issues. *

While GPS surveys were conducted, dense vegetation and terrain accessibility limited the extent of ground-truthing, which is essential for validating remote sensing interpretations.

Is there any potential for transferring this Good Practice to other cultural heritage organisations ? If so, please share more details. *

Yes, this Good Practice has strong potential for transfer to other cultural heritage organizations, especially those working in forested or hard-to-access archaeological landscapes. The methodology is based on widely available technologies—LiDAR data, open-source GIS software, and the Geomorphon algorithm—which makes it accessible and adaptable.

Key factors supporting transferability include:

Scalability: The approach can be applied to different spatial scales, from small sites to large regions, depending on data availability.
Replicability: The workflow—from LiDAR processing to visualization and pattern recognition—is well-documented and can be reproduced with minimal customization.
Open-source tools: Most of the software used (e.g., QGIS, SAGA GIS) is free and widely supported, reducing barriers to adoption.
Interdisciplinary applicability: The method can be integrated into existing archaeological, conservation, or heritage management workflows, and adapted to different cultural contexts.
Training potential: The approach can be taught through workshops or capacity-building programs, empowering local institutions to monitor and protect their heritage autonomously.

This practice is particularly valuable for institutions in regions where looting is a persistent threat and where traditional field surveys are limited by vegetation, terrain, or resources.

Additional Information. Please include below any other information or experience you wish to share.

None

The information provided will be used exclusively for the activities of the SATCULT project and within the rules and obligations defined by the GDPR rules. The EU General Data Protection Regulation (GDPR) regulates how personal data of individuals in the EU may be processed and transferred. *

- (●) I have taken note of this information and agree to the use of my responses within the SATCULT project.